# ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION

## Emergence, Attack Densities, and Seasonal Trends of Mountain Pine Beetle (Dendroctonus ponderosae) in the Black Hills

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Beetles began emerging around July 1 and emerged in peak numbers on August 15, 1966 and 1967. Adults emerged almost simultaneously from the north and south sides of trees. More beetles emerged from the south side at 1.5 feet aboveground than from the north side at the same height, but this relationship was reversed at heights of 5 feet and 10 feet. Densities of beetle attacks varied significantly with height and aspect. Brood densities declined drastically between the time of attack and the following May. Relationships between beetle emergence, evaluation techniques, and control operations are discussed.

Keywords: Dendroctonus ponderosae, Pinus ponderosa, insect habits.

The success of efforts to evaluate or control populations of mountain pine beetle, Dendroctonus ponderosae Hopkins (Coleoptera: Scolytidae), depends partially on coordinating the effort with a particular event in the beetle's life cycle. If chemicals are applied after beetles begin emerging, the efficiency of the control effort decreases each day thereafter. If bark samples are taken after emerging has begun, incorrect estimates of beetle trends may result. Thus, we need to know accurately the timing of events in the life cycle.

Unfortunately, there are no uniform dates for these events for the Rocky Mountain region because they vary with geographical location and fluctuations in climate and weather. Each specific area may have its own average dates for such events and even they may vary with weather conditions in a particular year. Since the habits and life cycle of the beetle vary, it is important that biological data from a given area be made known so evaluation and control procedures can be adjusted accordingly.

This Note is based on data gathered during a study of the predators of D. ponderosae in the Black Hills (Schmid 1968). It discusses the distribution of emerging beetles with respect

to time, aspect, and height on the tree bole, density of attacks, and seasonal trends of brood density within the lower 15 feet of infested trees.

### Study Area

The study area was located in the northern Black Hills of South Dakota, 2 miles southwest of Lead, in a 60- to 80-year-old second-growth stand of ponderosa pine (Pinus ponderosa Lawson). Dominant trees ranged from 10 to 20 inches diameter at breast height (d.b.h.), with the majority of the trees between 11 and 14 inches. Elevation of the area was between 5,700 and 5,800 feet.

### Methods

Screen cages were used to record the field emergence of D. ponderosae adults. Well before the 1966 beetle emergence, 21 cages (McCambridge 1964) were attached to 10 trees attacked in August 1965. Twelve were attached with the midpoints 4 feet aboveground; nine with the midpoints 10 feet or more aboveground. Each cage covered 5 to 6 square feet of bark.

Similarly, 78 cages were attached to trees attacked in August 1966. Six of these cages covered 5 to 6 square feet of bark each, and

were attached to three trees in October 1966. Midpoints of the cages were 4 feet aboveground. The other 72 cages covered 2 square feet each, and were attached to 12 trees during May and June 1967. Six cages were attached to each tree, three on the north and three on the south side at heights of 1.5, 5, and 10 feet aboveground. The cages were checked at 2- to 3-day intervals until D. ponderosae adults began emerging, and usually daily thereafter in both years.

Bark samples, 6 by 12 inches, were removed at 1.5, 5, 10, and 15 feet aboveground from 20 infested trees in both 1966 and 1967. The 20 trees were separated into two equal groups. Each group was sampled once during the August-October period following the attack of D. ponderosae, and then alternately on a weekly basis from May through August of the following year.

Number of attacks, inches of gallery, and live beetles were counted in each bark sample. The data from each group were combined for each year and then a square root transformation $\sqrt{x + 3/8}$, was applied to the data before analysis of variance with respect to trees, height, time, and the interactions of height and time. A significance level of 0.05 was used for the analyses.

### Results and Discussion

**Emergence**

Adults first emerged on June 29, 1966 and June 30, 1967. A few beetles emerged earlier, but this premature emergence probably was stimulated by cage attachment. The number of emerging beetles gradually increased during July and early August in both years, so that by August 5 approximately 10 percent of the beetles had emerged (figs. 1, 2). The mass emergence period began around August 10 in both years and continued until August 26 in 1966 and August 23 in 1967. The number of emerging beetles peaked on August 15 in both years, and fluctuated sharply from day to day. A few beetles (less than 0.2 percent of the total) emerged in September.

Daily emergence was affected by temperature, especially during the mass emergence period (figs. 1, 2). When maximum temperatures were 55° F. or lower, practically no beetles emerged; when maximum daily temperatures were above 55° F., the influence of temperature was less pronounced. Beetles emerging in a temperature range of 60° to 80° F. appear to be influenced more by factors such as the amount of cloud cover, relative humidity, and so forth, than by minor changes in maximum daily temperatures within this range.

Adults at the 5- and 10-foot heights emerged almost simultaneously from the north and south sides of infested trees in 1967; beetles at the 1.5-foot height usually emerged slightly earlier from the south sides.

The mean number (95 percent confidence interval) of D. ponderosae adults emerging per square foot of bark from the north and south sides of trees in 1967 was:

| Height (feet) | North | South |
|---|---|---|
| 1.5 | 16.5 ± 11.4 | 25.5 ± 10.6 |
| 5 | 30.8 ± 13.9 | 25.8 ± 15.0 |
| 10 | 30.9 ± 15.2 | 23.3 ± 8.6 |

The number emerging from the south side at 1.5 feet was significantly greater than the number emerging from the north side at that height. Differences between the north and south sides at the 5- and 10-foot heights were not significant although, on the average, more beetles emerged from the north sides.

The emergence information suggests several guidelines for the present methods of evaluating and controlling beetle infestations in the Black Hills. Since beetles may emerge in late June, control projects should end by July 20. Treatment of infested trees after July 20 becomes progressively less effective each day. Biological evaluations based on Knight's sequential sampling plan (Knight 1960) should also be completed by July 20. Samples taken after August 5 may give beetle estimates at least 10 percent low; this could result in an infestation being classified in a less important category. Since future research may also depend on accurately determining the time of emergence, the screen emergence cages should be in place by July 20.

Crews may continue their control or evaluation operations beyond July 20 if they know the beetles have not begun to emerge. However, these operations become progressively inefficient after July 20 and could lead to wrong conclusions about the status of the future infestation. It should also be stressed that the July 20 date is most applicable in the northern Black Hills, and should not be applied elsewhere without verification.

The placement of emergence cages on a specific side of a tree does not appear critical as long as the cages are placed around 5 feet aboveground, since the north and south sides

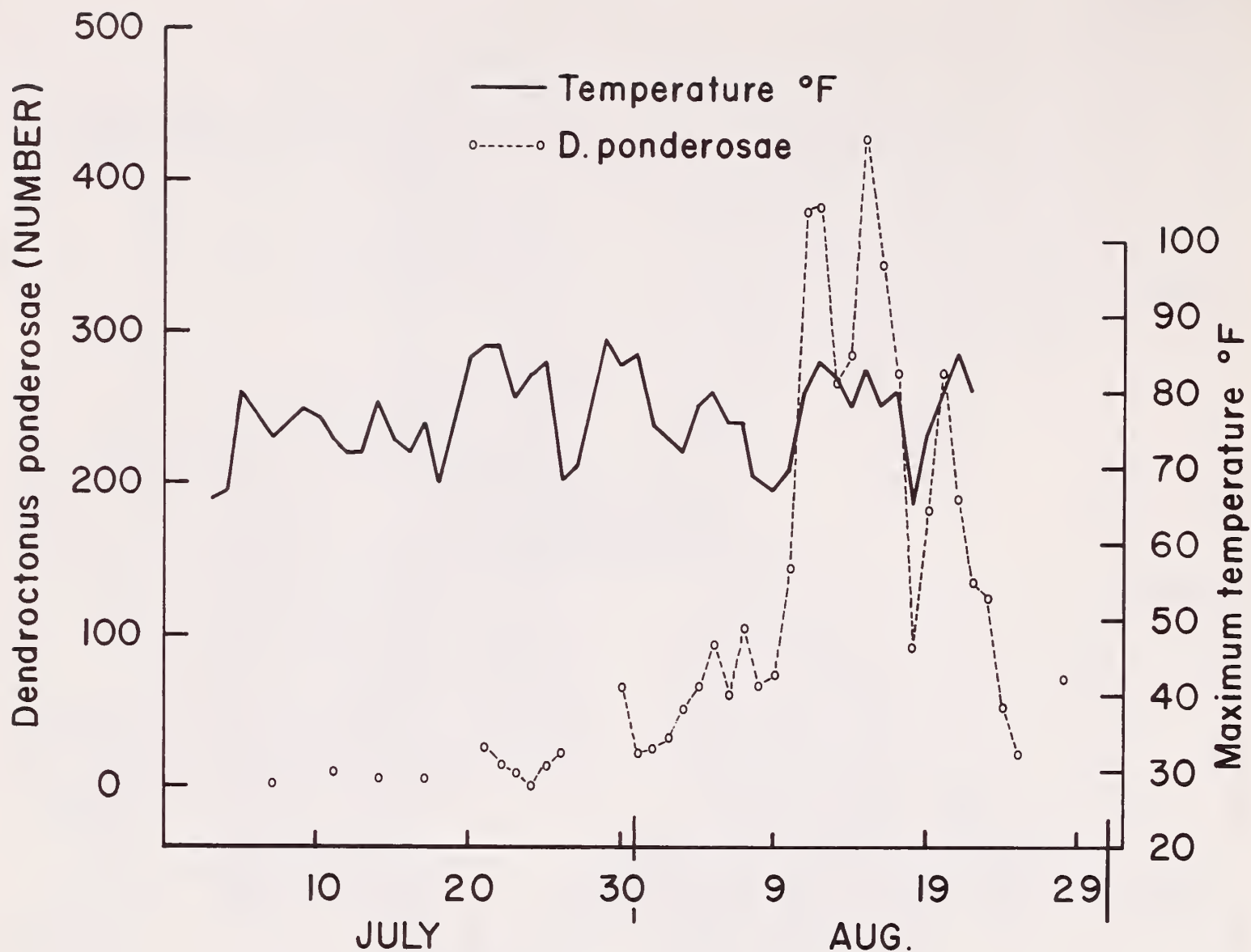Figure 1.--Numbers of beetles emerging daily in 1966.
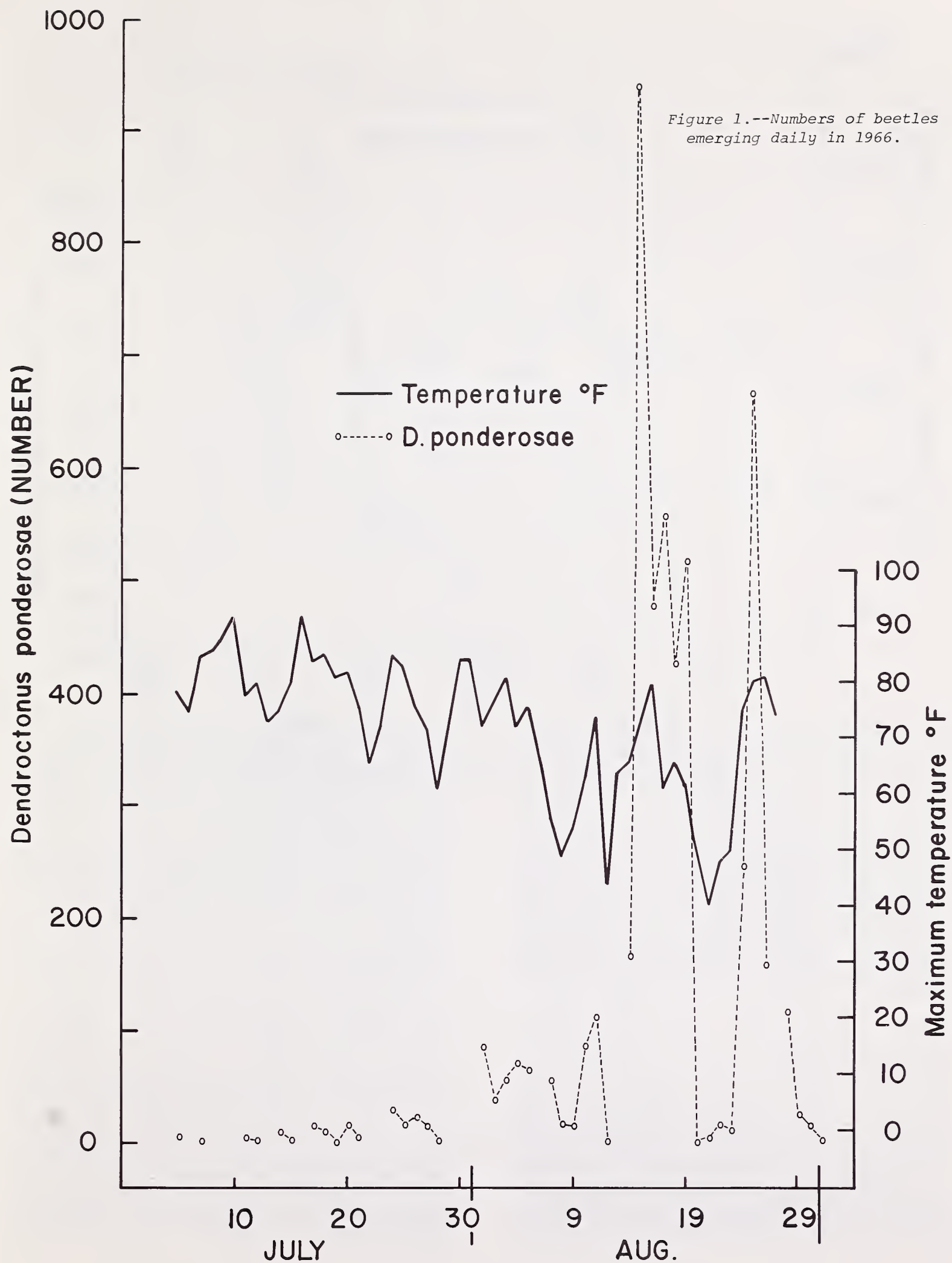
*Figure 2.--Numbers of beetles emerging daily in 1967.*

are not significantly different in either time or emergence or number of beetles. It may be preferable to place the cages on the north side because they produce a slightly greater number of beetles. This agrees with the observations of McCambridge (1964) on D. ponderosae in Colorado.

**Density of Attacks**

The density of attacks was significantly different between heights and aspects in both years. Interactions between the groups, heights, and aspects were not significant in either year.

The significant difference associated with height reflects the slight decrease in the mean density at the 15-foot level versus the mean

densities at the other levels (table 1). This results because beetles generally did not attack when the bole diameter became less than 8 inches. However, since the sample trees included a range of diameters 8 inches and greater at the 15-foot level, the rapid decrease in attacks is not immediately apparent.

The greater attack densities at the 5-foot level reflect characteristics of the flight behavior of the beetle. Beetles were observed flying into trees from 5 to 10 feet aboveground during initial attack. Many bounced off the tree and fell to the ground or lower on the tree. Then they began climbing up the tree and started their attack. Attack densities at the base of the tree probably reflect this behavior, and also explain why densities are nearly identical to those at the 5- and 10-foot levels.

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Table 1.--Mean number of attacks per square foot by aspect and height for 1965 and 1966 (95 percent confidence interval)

| Year | Height (feet) | Aspect | | | | Mean |
|------|------|------|------|------|------|------|
| | | North | East | South | West | |
| 1965 | 1.5 | 6.6 ± 0.34 | 6.8 ± 0.42 | 6.8 ± 0.38 | 6.4 ± 0.40 | 6.5 |
| | 5.0 | 7.0 ± .44 | 7.2 ± .34 | 7.0 ± .30 | 5.8 ± .50 | 6.8 |
| | 10.0 | 6.4 ± .36 | 5.9 ± .46 | 6.2 ± .54 | 5.2 ± .42 | 5.9 |
| | 15.0 | 5.0 ± .38 | 5.2 ± .34 | 4.1 ± .40 | 4.2 ± .44 | 4.6 |
| 1966 | 1.5 | 11.2 ± .78 | 10.0 ± .58 | 12.1 ± .46 | 11.1 ± -.64 | 11.1 |
| | 5.0 | 11.3 ± .66 | 10.9 ± .60 | ⁻11.3 ± .54 | 12.2 ± .56 | 11.4 |
| | 10.0 | 12.5 ± .62 | 10.5 ± .52 | 10.4 ± .52 | 11.2 ± .66 | 11.2 |
| | 15.0 | 11.1 ± .66 | 9.3 ± .68 | 9.1 ± .56 | 9.5 ± .72 | 9.8 |

The differences in attacks associated with aspect are not readily explainable. The west aspect in 1965 and the east in 1966 had lower mean densities and thus influenced the statistical tests. Why they had lesser attack densities is unknown, but it may be related to high temperatures and light intensities (Shepherd 1965).

Although interactions did not show significance, it is interesting to note the relationship between density of attacks on the north and south sides at different heights (table 1) and the number of beetles produced at those heights for 1967. The mean density of attacks on the south side was greater at the 1.5-foot height, equal at the 5-foot height and considerably less at the 10-foot height than the mean density of attacks on the north side at corresponding heights (table 1). Numbers of emerging beetles followed the same pattern, except numbers were greater at the 5-foot height on the north side. This indicates that up to the attack densities reported here, numbers of emerging beetles increase with increases in attack densities. Apparently, attack densities did not reach a point where the effects of competition begin to cause a decrease in numbers.

Attack densities may not always indicate competition or population trend. As Cole (1962) points out, other factors affecting young larvae could reduce the brood arising from extremely dense attacks (18 per square foot) to the point where competition is not important. Obviously, the densities reported here are similar to the "normal" densities of 9 and 7 per square foot reported by Cole (1962) and McCambridge (1967), respectively. However, as Miller and Keen (1960) suggest, beetles distribute their attacks so that overcrowding does not occur in any particular bark area. Furthermore, although the number of attacks varies considerably, it always remains within certain limits. In this case, it is apparent that the number of attacks is fairly uniform within the tree but varies from year to year (table 1). This distribution pattern probably results from attack-inhibiting behavior such as stridulation and pheromone masking. Rudinsky (1968) suggests that such behavior by D. pseudotsugae Hopkins prevents overinvasion of the host and resultant starva-

tion of the brood. D. ponderosae probably has a similar behavioral pattern, but I believe stridulation may be more important than Rudinsky indicates in determining the density of attacks. Males stridulating around the gallery entrance would not only warn males away, but could also keep other females from constructing their galleries too close to the initial gallery. Field observations also indicated that some beetles constructed considerable lengths of gallery without depositing many eggs when the number of galleries per sample became large. Bark samples with over 100 inches of gallery were not uncommon. These two behavior patterns thus prevented overcrowding and reduced the potential number of larvae before they began competing.
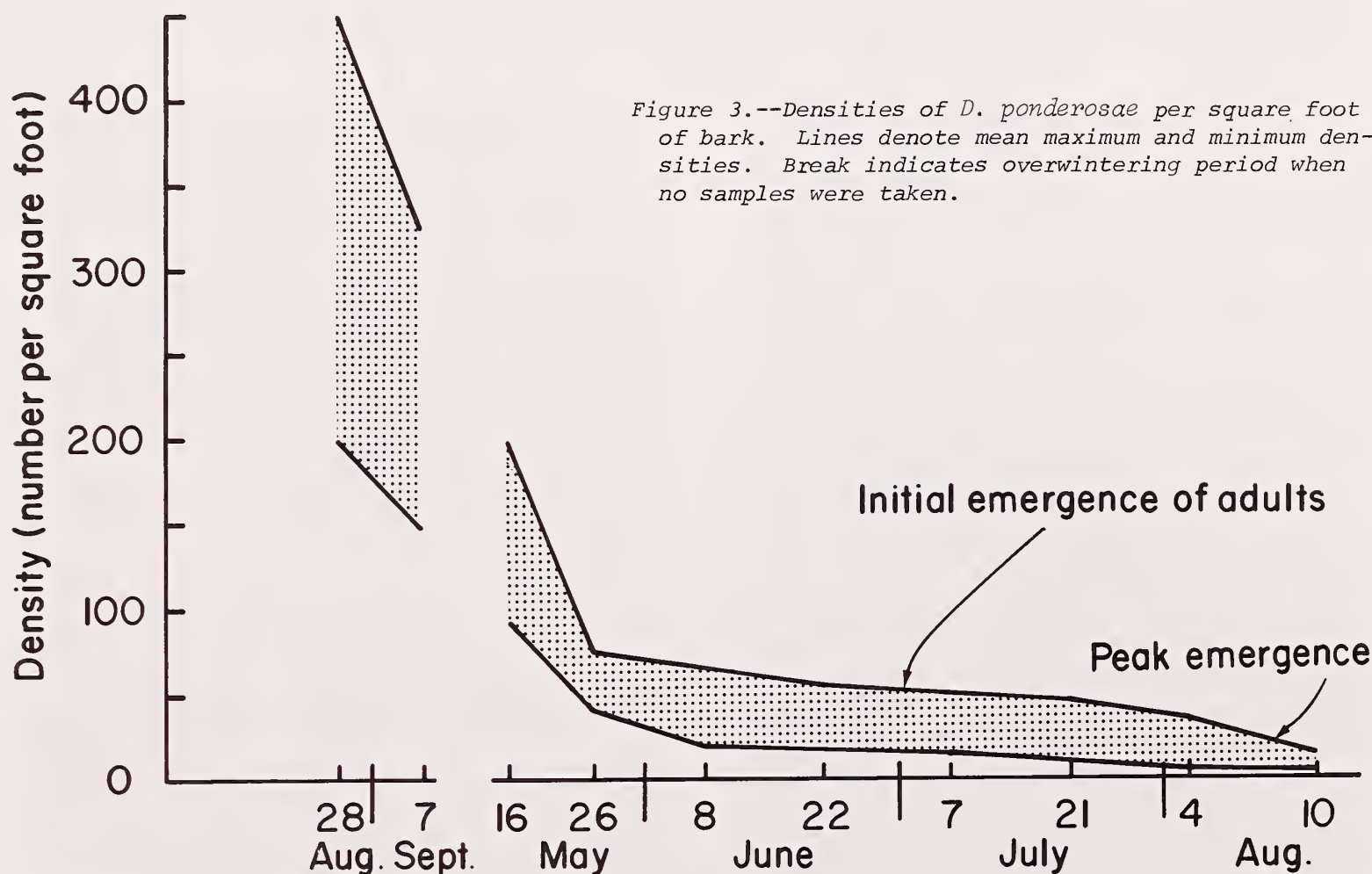
The number of attacks that will kill a tree will vary with tree diameter, attack density, and height of attack. Assuming that beetles attack rapidly and follow the patterns previously discussed, it is estimated that an 11-inch d.b.h. tree would be killed by 510 to 940 attacks. Similarly, 1,560 to 2,860 attacks would kill a 15-inch d.b.h. tree. Furthermore, assuming a 1:1 sex ratio, this means that each 11-inch d.b.h. tree would absorb about 1,000 to 1,900 beetles while each 15-inch d.b.h. tree would absorb approximately 3,100 to 5,700 beetles. Numbers of beetles absorbed by trees of other diameters can be estimated by multiplying the total bark surface subject to attack by the mean density of attacks in table 1.

No new attacks were found after the overwintering period although less than 0.1 percent of the parent adults were extending galleries.

**Brood Densities**

The density of beetles changed drastically during development of the brood (fig. 3). Densities were highly variable shortly after attack, and most declined by at least 50 percent between time of attack and the following May. These two factors indicate why predictive sampling plans are not effective during this period.



Figure 3.--Densities of D. ponderosae per square foot of bark. Lines denote mean maximum and minimum densities. Break indicates overwintering period when no samples were taken.

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Densities gradually declined after the first of June. The difference between the maximum and minimum densities narrowed from June until beetles began emerging. Knight's sequential sampling plan (Knight 1960) is best applied during July when beetle densities are most similar and the least number have left the tree. The minor changes in brood densities after late May indicate that Knight's plan could be modified for control-no control decisions in late May.

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